Simulating strategic information systems planning process using fuzzy cognitive map

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Abstract: Strategic information systems planning (SISP) is one of the key factors in modern information age. Proposition of different methods for strategic information system planning baffle the organisations about using which of them. The problem here is the complexity of dealing with strategic information system planning due to superabundant factors engaged in it. In this paper the applications of fuzzy cognitive maps (FCMs), as decision making and modelling tool, in SISP context have been discussed. The objective is to simulate and represent the factors affecting the planning process which is considered both a tool and a need in today's competitive society. The resulting SISP fuzzy cognitive map gives a clear perception of factors affecting the planning process and their relations which help decision-makers and planners analyse and come to their related decisions and plans.

Keywords: strategic information system planning; fuzzy cognitive map; FCM; simulation; decision-making; Delphi method.

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1 Introduction

The dynamic and uncertain nature of today's environment entails observation on many levels, of the structural, business, to technological environment. New patterns of interaction within organisations, such as moving from vertical integration to outsourcing, and to virtual organisations, allow the development of strategic alliances and partnerships that enable firms to focus on their core competencies. Organisations are changing in response to these needs by becoming flat, fast, flexible, adaptive, collaborative and information-intensive structures, by using information technology (IT) (Bechor et al., 2010). In this era, rapid advances in open networks and IT capabilities are greatly increasing environmental complexity and uncertainty. Indeed, they are altering industry structures, creating competitive advantages, spawning new businesses, and, as a result, continuously shaping and reshaping the business environment (Porter, 2001).

At the same time, competitors are producing new products and services, and vigorously marketing them. Customers are becoming more selective in their choices of those products and services. Governments are passing more and more legislation regulating organisations, while suppliers increasingly attempt in innovative ways to obtain the highest possible prices for their raw materials. All the while, competitors are assessing these changes in the external environment for their own strategic business planning, and thus forcing other organisations to do likewise (Chi et al., 2005). The impact of these trends on strategic management has been to estimulate the adoption of system thinking, i.e., management of the entire strategy process and its components. Hence, preliminary strategic planning activities is a must to successfully conform the ITs (Mohdzain and Ward, 2007).

Strategic information systems planning (SISP) is an important management function. It can help an organisation use IT more competitively, identify new, higher payback IT applications, and better forecast IT resource requirements. On the other hand, the failure to perform SISP well can cause opportunities to be missed and efforts to be duplicated. It can result in incompatible systems and wasted resources. In fact, today's highly competitive environment, with its rapidly changing IT, may aggravate the dangers of ineffective SISP more than ever before (Basua et al., 2002).

SISP has been the concern of academics and practitioners for nearly 20 years (Duhan, 2007). It is among the highest ranked issues on management agendas for many years (Teubner, 2007). While studies have indicated the important effect of context on IS planning, the incorporation of contextual factors has not been general and categorisation of the factors has not been made explicit while some factors have only been superficially examined (Cohen, 2008). In other words, the problem here is the complexity of dealing with factors affecting and involving the in the planning process. With information societies flourishing, as one of the characteristics of the modern millennium, social interactions are becoming more complex and vague. It is apparent that decisions which, until a few decades ago, could have been made very easily, now lead to very complicated equations and formulas. This is noticeable in all aspects of the human society, in politics, economy, culture, etc. Due to the existence of these ambiguities and the numerous variables involved in decision making, fuzzy cognitive map (FCM) has been introduced as a new approach to changing the decision-making into a clearer process. Using the FCM technique, we can observe the significance of each factor and its influence on other factors and the final plan. Furthermore the FCM fills the gap between strategic information systems and SISP. This is not possible with current practices (Bueno and Salmeron, 2008).

The objective in this paper is to establish a FCM which represents the factors affecting SISP and the relevance between these factors. The proposed map helps the decision makers and planners have a clear picture of affecting factors and their relation in the context of SISP. The opinions of the experts in the IT context have been elicited in order to identify the FCM.

The remainder of this paper is structured as follows. In Section 2 a review of the background of SISP. In Section 3 the necessary explanations about FCM have been given. In Section 4 we have described the methodology and the way in that the research has been conducted. The details and exact steps toward developing the FCM, including identifying the factors, determining their relations and defining the linguistic fuzzy weights, have been thoroughly explained in Section 5. At the end of this section, proposed SISP FCM has been introduced. In Section 6 we have discussed the results and findings. Finally, concluding remarks have been provided in the last section, as well as the limitations and future research lines.

2 Strategic information systems planning

2.1 Strategic information systems

During the last three decades, an area has developed within the field of information systems (IS) which is generally referred to as a strategic information system (SIS). This new area mainly focuses on systems whose importance to the organisation is more than merely assisting it to perform its existing functions and operations efficiently, or even just effectively. A SIS is instrumental in the organisation's achievement of its competitive or other strategic objectives (Shirazi and Soroor, 2007). In order for a system to be called strategic, it must significantly change business performance, the means the business employs to attain a strategic goal, the way a corporation does business, the way it competes, or the way it deals with customers or suppliers (Ernst and Chen, 1994).

Organisations are now investing extensively in IS to obtain maximum benefits of IT. But ISs are often deemed unsuccessful due to lack of alignment between IS and business planning; huge divergence in the approaches adopted by different enterprises in time, cost, and environmental factors and ignoring of IS project management activities in most enterprises (Garg et al., 2008). According to Shirazi and Soroor (2007) an IS could be considered as a SIS if it is aligned with business goals and strategies and if it has an impact on organisational performance. In other words, the difference between SIS and other ISs such as transaction processing system (TPS), management information system (MIS), and decision support system (DSS) is that the new focus is on strategy.

However, the competitive advantage that a corporation may gain by using SISs is not risk-free. A corporation using SIS may lose competitive advantage by shifting the basis of competition in an unfavourable direction, lowering entry barriers, bringing on litigation or regulation, or increasing the power of suppliers and customers relative to the corporation (Tan et al., 1995). Therefore, it is vital to consider all factors surrounding the development of strategic information systems in order to achieve substantial competitive advantage, which makes the planning phase imperative (Min et al.., 1999).

Neumann (1994) provides a comprehensive definition of SIS. He states:

> "the primary function of an SIS is to support [or shape] the competitive strategy of a company in its industry and its plan for gaining or maintaining competitive advantage, or reducing its competitive disadvantage relative to its rivals. An SIS provides or contributes to competitive advantage if it provides a greater return on investment for a company than its industry's average return".

He adds "it is not the systems that make the difference but the use for which and the methods by which the SIS are developed." Also Neumann identifies four fundamental characteristics of SISs that set them apart from other types of information systems. These characteristics are: "they are change the way a firm competes, they have external focus, they are associated with a higher project risk, they are innovative [in use of IT]".

Besides, it is to be noted that understanding SIS implementation is an important challenge to organisations. It is considered important because IT decisions about investment are made worldwide and these decisions have the impact on the survival and growth of the organisations. In this context, SIS should be implemented very carefully so that right, timely and accurate information should be available to the managers, who are responsible for taking strategic decisions (Rishi and Goyal, 2008).

2.2 Strategic information systems planning

SISP was identified as a critical management issue in the 1990s and is still ranked high as a critical issue today of key issues in IS management (Bechor et al., 2010). Since its introduction, SISP has never been abandoned, and SISP is going to be a long-lasting need within an organisation (Pita et al., 2008). SISP refers to the process of identifying a portfolio of computer-based applications that will support an organisation's business plans, thus enabling the organisation to align its ISs with its business needs and achieve its business goals (Reich and Benbasat, 2000). SISP can be viewed as consisting of five phases: planning the SISP study process, assessing the environment, conceiving strategy alternatives, selecting a strategy, and finally, planning the implementation of the strategy (Mentzas, 1997; Chi et al., 2005). The purposes and motivations of SISP have been mentioned by Duhan (2007) as follows:

- aligning investment in IS with business goals
- exploiting IT for competitive advantage
- directing efficient and effective management of IS resources
- developing technology policies and architectures.

Although many organisations conduct such a formal planning process, others do not. Instead, they practise a more informal approach with continuous adaptation to the availability of resources in the presence of environmental threats and opportunities (Vitale et al., 1986). Planning is based on a dynamic administrative process to ensure continuous alignment between business and IT management (Venkatraman et al., 1993). Planning evolves as the result of decisions based on the use of particular methods and to fit current needs (Earl, 1993). In extreme cases, managers may merely 'muddle through' (Lindblom, 1959) to find satisfactory solutions to exigent problems (Cyert and March, 1963; Cohen et al., 1972; March and Olsen, 1979). With such piecemeal planning, shifting priorities may impede the development of large-scale systems (Lederer and Mendelow, 1993; Lederer and Salmela, 1996).

One of the major issues on the IS planning agenda is choosing the right methodology to enable the IS team to plan and track its SISP activities. A SISP methodology is comprised of one or more techniques where each technique is defined by a set of practices, procedures, and rules. Generally, the use of more than one methodology is preferred. The main methodology selection criteria include resource availability, methodology/technique complexity, internal policy, historical reasons, a preferred supplier, familiarity, etc. The use of automated tools also helps planners to conduct SISP in a structured and more efficient way (Pita et al., 2008).

Realising the importance of SISP, several researchers have proposed SISP models to guide business organisations. Many studies have also revealed factors motivating and inhibiting SISP projects (Ismail et al., 2007). In other words, most of previous researches centred on SISP success, and its factors and problems, the effect of top management support, SISP process, IS planning methodologies and approaches, planning horizon, business change, IT change, and their alignment, and various other aspects of the planning process (Bechor et al., 2010). However, very little is known about the contextual factors of SISP process. Therefore, this study attempts to fill this gap by utilising FCM as a powerful instrument to simulate the planning process.

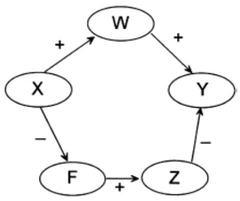
3 A brief review of FCMs

In this section, the necessary theories about the concepts of s are described in order to support the readers of the paper with the essential background they need.

Cognitive maps (CMs) were proposed and applied to ill-structured problems by Axelrod (1976). Axelrod develops CM's, i.e., signed digraphs designed to capture the causal assertions of a person with respect to a certain domain and then uses them in order to analyse the effects of alternative, e.g., policies, business decisions, etc. upon certain goals. Axelrod presents case studies in the policy domain. A cognitive map has only two basic types of elements: concepts and causal beliefs. The concepts are represented as variables and the causal beliefs as relationships among variables.

Causal relationships link variables to each other and they can be either positive or negative. Variables that cause a change are called *cause variables* while those that undergo the effect of the change in the cause variable are called *effect variables*. If the relationship is positive, an increase or decrease in a cause variable causes the effect variable(s) to change in the same direction. If the relationship is negative, then the change which the effect variable undergoes is in the opposite direction. Figure 1 is a graphical representation of a cognitive map, where variables (X, W, etc.) are represented as nodes, and causal relationships as directed arrows between variables, thus constructing a signed digraph.

Figure 1 An example of cognitive map



Cognitive maps were developed in simulation, organisational strategies modelling, support for strategic problem formulation and decision analysis, knowledge bases construction, managerial problems diagnosis, failure modes effects analysis, modelling of social and psychological processes, modelling virtual worlds and analysis of their behaviour, requirements analysis and systems requirements specification. (Kardaras and Karakostas, 1999).

Kosko (1986) introduces FCM i.e., weighted cognitive maps with fuzzy weights. It is argued, that FCM eliminate the indeterminacy problem of the total effect. Since its development, fuzzy set theory has been advanced and applied in many areas such as experts systems and decision making, control engineering, pattern recognition, etc (Zimmermann, 1991). It is argued that people use fuzzy data, vague rules, etc. and fuzzy sets as a mathematical way to represent vagueness (Bezdek, 1993). Fuzzy sets are characterised by a membership function, which is also called the degree or grade of membership.

Different approaches were proposed for the specification of the fuzzy weights in an FCM (Taber, 1991). One suggestion is to ask the experts to assign a real number from the interval (0, 1) for each relationship and then calculate the average. However, it is difficult for the experts to assign a real number in order to express their beliefs with regard to the strength of relationships. This is the reason why partially ordered linguistic variables such as weak < moderate < strong, etc. are preferred instead of real number. It is assumed that a concept in an FCM can be represented by a numerical vector (V), whereas each element (v) of the vector represents a measurement of the concept.

Another way of representing a cognitive map is possible through an adjacency matrix where one can clearly observe the sign of the relationship, while keeping in mind that in case of there being an absence of relationship between these two factors, the corresponding entry will be empty. Figure 2 shows this matrix (E) that represents an example of a cognitive map (Bueno and Salmeron, 2008).

Figure 2 Adjacency matrix associated with a cognitive map

E=

	W	X	Y	Z
W		+		
X				+
Y		-		
Z				

4 Research method

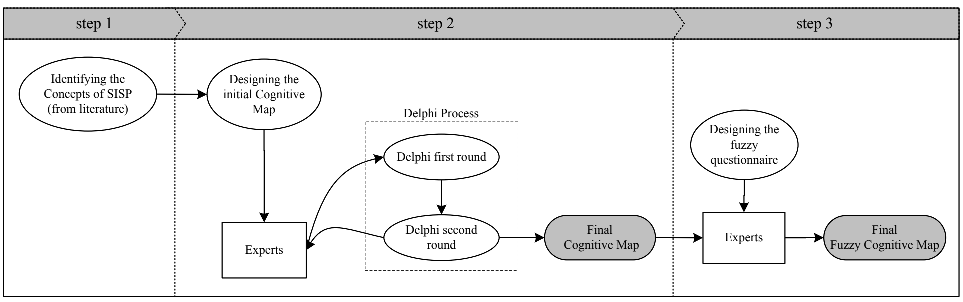
The proposed FCM in this paper considers the variables determining the strategic information systems alternative paths and the relationships among them. Each mutual relationship includes one linguistic fuzzy weight which determines the accuracy of the expert choice. The model includes 58 variables and 61 relationships. Aiming to develop the FCM, the research has been done through three steps:

In Step 1, the variables have been identified by studying and analysing the literature of SISP.

In Step 2, we have used a panel of 15 experts to determine the relation between factors. This has been accomplished through a two round Delphi process to reach a consensus among experts. Step 2 leads to obtain the SISP cognitive map (but not a fuzzy one).

In Step 3, the obtained cognitive map has been extended to a FCM by establishing linguistic fuzzy weights for each relation. To identify the linguistic fuzzy weights, a 60 point (as many as the number of relationships) fuzzy questionnaire has been designed and used to collect the opinions of another panel of experts. 70 experts in the fields of strategic management, information systems and software engineering have asked to fill out the questionnaire and 62 of them done this. Then, based on the output of questionnaire, by using the fuzzy toolbox in MATLAB software, the linguistic fuzzy weights have been established. At the end of step 3, we are able to propose the FCM regarding SISP. Figure 3 expresses the steps of research using a schematic representation.

Figure 3 Schematic representation of research



In the next section of this paper, we will completely explain the above steps and the way the research has been conducted.

5 Using FCMs in simulating the SISP

5.1 Step 1: Identifying the factors of model

After reviewing a host of factors corresponding to SISP discussed in (Leem and Oh, 2001; Cohen, 2008; Bechor et al., 2010; Kunnathur and Shi, 2001), nine main items which include subcategories were reached. The main items are as follows:

1 business strategy

2 IS strategy

3 IT strategy

4 heterogeneity

5 hostility

6 dynamism

7 planning team involvement

8 user and management involvement in IS planning

9 implementation problem.

In next section we are going to determine how these factors affect each other and SISP.

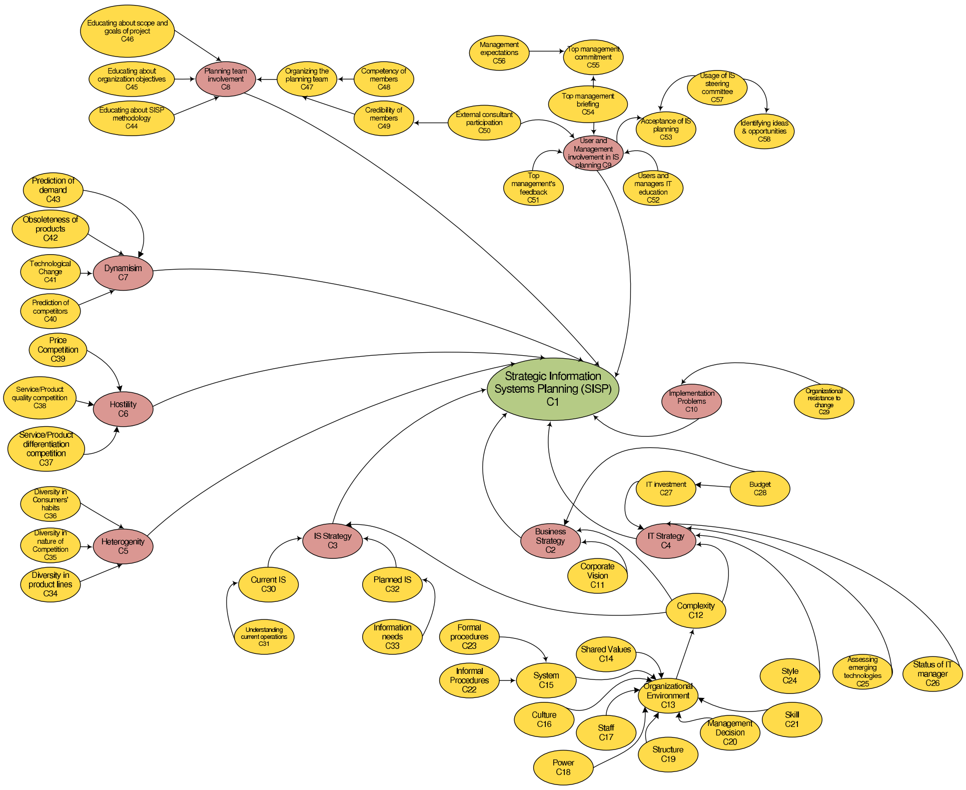
5.2 Step 2: Identifying the relation between factors and prepare the SISP cognitive map using Delphi methodology

The objective of this step is to understand and define the relation between SISP factors which have been identified in the previous step. When the factors and their relations are clearly recognised, it is possible to establish the cognitive map of SISP.

With the purpose of determining the relation between factors, advice was taken from a panel of 10 experts. These experts are selected based on their academic background and long time experiences in information systems as well as strategic planning consulting or managerial positions. This team composition guarantees the experts who are finally chosen having profound knowledge of SISP models. The optimal number of experts depends on the characteristics of the study itself. However, one of the most recent studies suggests a range of 10 to 18 to be an ideal number for each panel of experts (Okoli and Pawlowski, 2004).

Among various techniques (Bryson et al., 1997) available in order to reach a consensus among the experts, we have adopted the Delphi methodology. The Delphi methodology is a method used to structure the process of communication in a group of experts in order to reach a consensus regarding a complex problem. One of the main characteristics of the Delphi study is when the experts receive feedback reports, they have the opportunity of improving their own opinion based on this feedback (Dalkey and Helmer, 1963). This was done through consulting with two rounds of questioning which provided the experts with information about deviations from previous rounds to provide them with the chance to obtain consensus and get all experts to go toward the average (Bueno and Salmeron, 2008).

Figure 4 Initial (draft) cognitive map (see online version for colours)



In order to obtain the relation between factors, according to aforementioned factors retrieved from literature survey and the consultation with one of the most qualified experts, we prepared the initial (draft) version of the cognitive map. This map represented the relations between affecting factors in SISP (Figure 4).

After that, to perform Delphi first round, we arranged separate consultation interviews with each expert. In each session, after giving necessary explanations to the expert, we asked him/her to carefully study the relations between factors presented in the draft cognitive map and advise his/her comments and corrections. They were also asked to determine the sign of relation (positive or negative). They put P for positive relation and N for negative relation. If they did not believe in a relation between any two factors, they announced it by putting no relation (NR) for the relation.

After doing the first round, we had the results represented in Table1 (the results from the first round of Delphi process).

Table 1 The frequency of responds by experts (Delphi first round results)

Relation	*Positive relation*	*Negative relation*	*No relation*
C2-C1	11	3	1
C3-C1	10	2	3
C4-C1	14	-	1
C5-C1	11	2	2
C6-C1	8	4	3
C7-C1	14	1	-
C8-C1	12	2	1
C9-C1	13	2	-
C10-C1	10	5	-
C11-C2	14	1	-
C12-C2	-	14	1
C12-C4	2	13	-
C12-C3	1	14	-
C13-C12	10	4	1
C14-C13	11	4	-
C15-C13	14	1	-
C16-C13	12	3	-
C17-C13	11	3	1
C18-C13	9	2	4
C19-C13	14	1	-
C20-C13	15	-	-
C21-C13	12	3	-
C22-C15	15	-	-
C23-C15	15	-	-
C24-C4	4	-	11
C25-C4	15	-	-
C26-C4	15	-	-
C27-C4	11	3	1
C28-C27	13	2	-
C28-C2	10	2	3
C29-C10	14	1	-
C30-C3	12	3	-
C31-C30	13	2	-
C32-C3	14	1	-
C33-C32	14	1	-
C34-C5	8	3	4
C35-C5	11	2	2

Table 1 The frequency of responds by experts (Delphi first round results) (continued)

Relation	*Positive relation*	*Negative relation*	*No relation*
C36-C5	15	-	-
C37-C6	15	-	-
C38-C6	12	2	1
C39-C6	15	-	-
C40-C7	13	1	1
C41-C7	12	2	1
C42-C7	10	2	3
C43-C7	11	1	3
C44-C8	15	-	-
C45-C8	15	-	-
C46-C8	11	3	1
C47-C8	14	1	-
C48-C47	2	-	13
C49-C47	14	1	-
C50-C49	11	3	1
C50-C9	12	2	1
C51-C9	15	-	-
C52-C9	15	-	-
C9-C53	15	-	-
C54-C9	9	4	2
C54-C55	11	3	1
C56-C55	12	2	1
C57-C53	15	-	-
C57-C58	13	2	-

In addition, some experts believed in new relations between some factors that had not been taken into account in the initial cognitive map. These relations are addressed in Table 2.

Table 2 New relations addressed by experts (in Delphi first round)

Relation	*Positive relation*	*Negative relation*
C24-C13	9	-
C58-C9	11	-
C48-C49	10	-

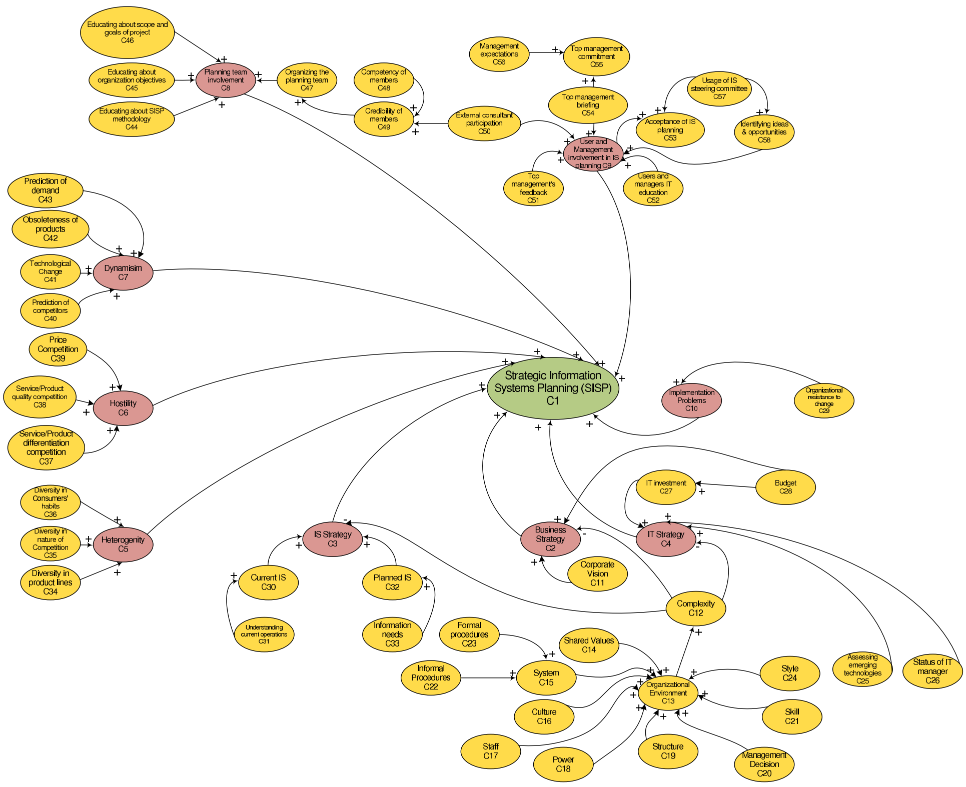
In the results obtained from Table 1 and Table 2, one can observe that the experts attained a majority consensus in the total of the relationships. In this sense, in most cases the total number of experts has responded in the same way, or rather only four or fewer experts have disagreed with the majority.

According to the consequences of first round of Delphi methodology, we found out the some improvements and corrections are needed in the initial cognitive map. Results showed that majority of experts did not agree with the relations between ‘style’ and ‘IT strategy’ and they preferred the relation between ‘style’ and ‘organisational environment’. So the relation (C24-C4) was replaced by relation (C24-C13). Similarly, experts argue that the relation between ‘competency of members’ and ‘credibility of members’ is more meaningful than the relation between ‘competency of members’ and ‘organising the planning team’. So the relation (C48-C47) was corrected to relation (C48-C49).

Furthermore, experts introduced one more relation between ‘identifying ideas and opportunities’ and ‘user and management involvement in IS planning’. Thus, relation (C58-C9) was added to the model.

After applying the above revisions, we started the second round of Delphi. The revised cognitive map was sent to the experts through an e-mail. In addition, the frequency of response in the first round was declared in the e-mail. They were asked to explore the relations in the new cognitive map and insert their opinions. The instruction for giving the advised was the same as first round (P for positive, N for negative and NR for absence of relation). Also, it was possible for them to introduce new relations if applicable.

Figure 5 Final SISP cognitive map (see online version for colours)



The results of Delphi second round is collected in Table 3. It is concluded from this table that the experts have made some compromises. Also a larger consensus than the first round can be observed. In these cases a consensus is reached either because the experts are influenced by the others in the second round, or because they have realised that their previous opinion was erroneous.

When Delphi methodology is applied, a consensus is reached when most of the opinions are found within the interquartile range (Linstone and Turoff, 1975). The results from Table 3 show that in all relations the majority of the experts' opinions have been found to be within the interquartile range. This outcome allows us to claim that the expert positions have come close enough. Based on this analysis, it is possible to propose the cognitive map as the final result. This final costumed SISP cognitive map is presented in Figure 5.

The purpose of the next step is to extend this cognitive map to a FCM.

Table 3 The frequency of responds by experts (Delphi second round results)

Relation	*Positive relation*	*Negative relation*	*No relation*
C2-C1	11	3	1
C3-C1	10	2	3
C4-C1	14	-	1
C5-C1	11	2	2
C6-C1	8	4	3
C7-C1	14	1	-
C8-C1	12	2	1
C9-C1	13	2	-
C10-C1	10	5	-
C11-C2	14	1	-
C12-C2	-	14	1
C12-C4	2	13	-
C12-C3	1	14	-
C13-C12	10	4	1
C14-C13	11	4	-
C15-C13	14	1	-
C16-C13	12	3	-
C17-C13	11	3	1
C18-C13	9	2	4
C19-C13	14	1	-
C20-C13	15	-	-
C21-C13	12	3	-
C22-C15	15	-	-
C23-C15	15	-	-
C24-C13	15	-	-
C25-C4	15	-	-
C26-C4	15	-	-
C27-C4	11	3	1
C28-C27	13	2	-

Table 3 The frequency of responds by experts (Delphi second round results) (continued)

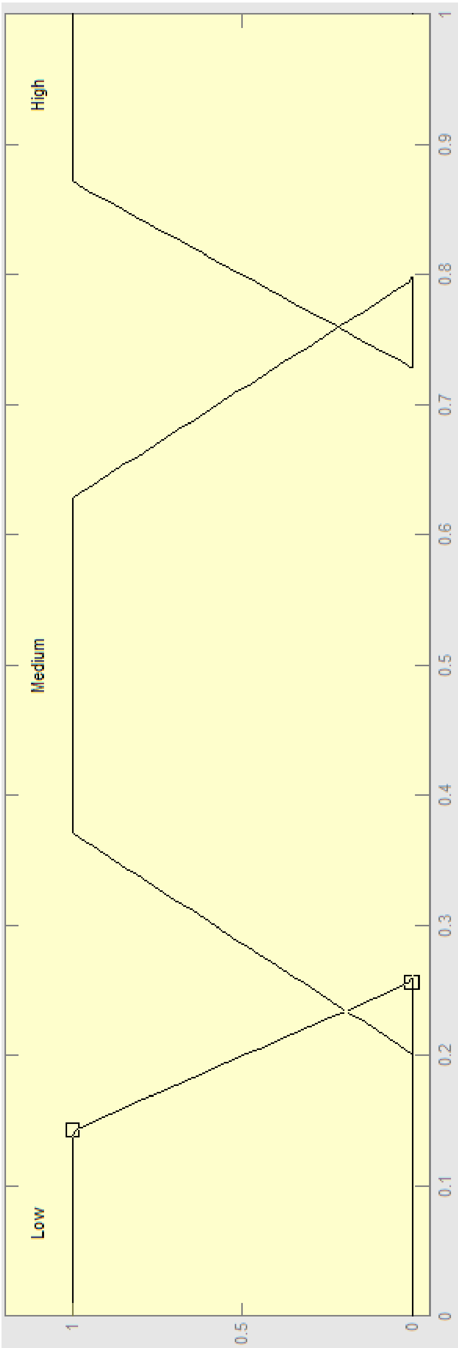
Relation	*Positive relation*	*Negative relation*	*No relation*
C28-C2	10	2	3
C29-C10	14	1	-
C30-C3	12	3	-
C31-C30	13	2	-
C32-C3	14	1	-
C33-C32	14	1	-
C34-C5	8	3	4
C35-C5	11	2	2
C36-C5	15	-	-
C37-C6	15	-	-
C38-C6	12	2	1
C39-C6	15	-	-
C40-C7	13	1	1
C41-C7	12	2	1
C42-C7	10	2	3
C43-C7	11	1	3
C44-C8	15	-	-
C45-C8	15	-	-
C46-C8	11	3	1
C47-C8	14	1	-
C48-C49	13	2	-
C49-C47	14	1	-
C50-C49	11	3	1
C50-C9	12	2	1
C51-C9	15	-	-
C52-C9	15	-	-
C9-C53	15	-	-
C54-C9	9	4	2
C54-C55	11	3	1
C56-C55	12	2	1
C57-C53	15	-	-
C57-C58	13	2	-
C58-C9	11	2	2

5.3 *Step 3: Specifying the fuzzy weights and provide the fuzzy SISP cognitive map*

Up to the previous step, the cognitive map of SISP has been produced. In this cognitive map, no certain strengths for casual relations between factors are considered. The objective of this step is to provide such strength for the relations using the fuzzy set theory.

To do this, each mutual relationship includes one linguistic fuzzy weight which determines the accuracy of the expert choice.

Figure 6 Linguistic fuzzy variables (see online version for colours)



It is proposed that linguistic fuzzy weights be used instead of real values for weights (Zhang et al., 1989) and (Zhang et al., 1992), as the linguistic fuzzy weights make it easier for the planners to express their beliefs. These linguistic fuzzy weights bring about a more thorough and understandable vision for the decision makers by mapping the ideas of the experts into a logic which could be processed (Klir and Youan, 2005).

To identify the linguistic fuzzy weights, a 61 point (as many as the number of relationships) questionnaire has been designed.

From the total of 62 experts (among 70 selected experts) of these branches filled out the questionnaire and assigned fuzzy weights to all of the relations in the cognitive map, in order to express their beliefs in the strength of a certain causal relationship as being strong, moderate, or weak. The corresponding fuzzy weights ranging between (0, 1) are shown in Figure 6. It is considerable which, this fuzzy number could be tune during the implementation of given FCM by a feedback processes.

Fuzzy weights in our FCM show the belief which planners share with regard to the existence of a certain relationship, and not the magnitude of change that a variable may undergo because of its causal relationship with other variables. Planners during modelling should answer the following question for each relationship:

How strongly, do you believe, the causal relationship between variable (X) and variable (Y) is?

The quantity space of the relationships' weights Q(w), is the following set: Q(w): {undefined; weak; moderate; strong}.

It is assumed that the following ordering applies for Q(w): {weak < moderate < strong}.

The important point in this paper is that there are no intersections among the three sets of weak, moderate, and strong.

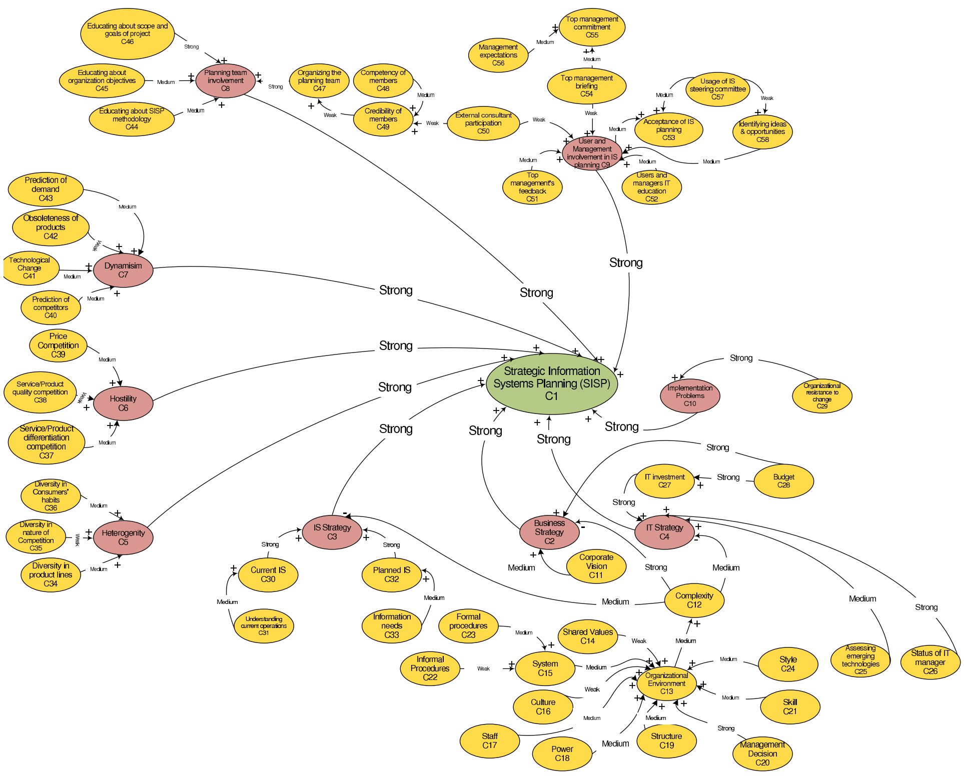
Table 4 The linguistic fuzzy weights for relationship strengths between factors

Relation	*Relation strength*	*Relation*	*Relation strength*
C2-C1	Strong	C30-C3	Strong
C3-C1	Strong	C31-C30	Medium
C4-C1	Strong	C32-C3	Strong
C5-C1	Strong	C33-C32	Medium
C6-C1	Strong	C34-C5	Medium
C7-C1	Strong	C35-C5	Weak
C8-C1	Strong	C36-C5	Medium
C9-C1	Strong	C37-C6	Medium
C10-C1	Strong	C38-C6	Weak
C11-C2	Medium	C39-C6	Medium
C12-C2	Strong	C40-C7	Medium
C12-C4	Medium	C41-C7	Medium
C12-C3	Medium	C42-C7	Weak
C13-C12	Medium	C43-C7	Medium
C14-C13	Weak	C44-C8	Medium
C15-C13	Medium	C45-C8	Medium
C16-C13	Weak	C46-C8	Strong
C17-C13	Medium	C47-C8	Strong
C18-C13	Medium	C48-C49	Medium
C19-C13	Medium	C49-C47	Weak

Table 4 The linguistic fuzzy weights for relationship strengths between factors

Relation	*Relation strength*	*Relation*	*Relation strength*
C20-C13	Strong	C50-C49	Weak
C21-C13	Medium	C50-C9	Weak
C22-C15	Weak	C51-C9	Medium
C23-C15	Medium	C52-C9	Medium
C24-C13	Medium	C9-C53	Medium
C25-C4	Medium	C54-C9	Weak
C26-C4	Strong	C54-C55	Medium
C27-C4	Strong	C56-C55	Medium
C28-C27	Strong	C57-C53	Medium
C28-C2	Strong	C57-C58	Weak
C29-C10	Strong	C58-C9	Medium

Figure 7 Final 'SISP FCM' (see online version for colours)



To aggregate the answers collected from experts, the Mamdani fuzzy operator has been applied. By aggregating the answers with the aid of fuzzy toolbox in MATLAB software, the following results have been obtained (Table 4).

In Figure 7, we have put the obtained fuzzy linguistic weights on each relation. This FCM is the final result that covers the objective of reaching a 'SISP cognitive map'.

6 Discussion

FCM is a computing technique for modelling complex systems, which follows an approach similar to human reasoning and the human decision-making process. FCMs can successfully represent knowledge and human experience; introduce concepts to represent the essential elements and the cause and effect relationships among the concepts to model the behaviour of any system. It is a very convenient, simple, and powerful tool, which is used in numerous fields.

Using the FCM to determine the SISP proves useful and looks promising for a move from the conventional modelling toward developing computer based models. The FCM is the only model that is capable of considering all the variables involved in the determination of the planning process factors and the relationships among them. It is also capable of showing the dynamics involved in the planning process determination. The proposed model enables the experts to simulate different ideas from various viewpoints.

Another distinct characteristic of this model is its capability to react to changes in the factors involved in determining strategic information system plans.

In this approach, we utilise fuzzy linguistic labels instead of real numbers to determine the weights. This makes the FCM even more sensible.

The obtained FCM emphasises the importance of the three main factors of planning process including business strategy, IS strategy, IT strategy, heterogeneity, hostility, dynamism, planning team involvement, user and management involvement in IS planning, implementation problem by identifying their impacts as “strong” impacts on satisfying the customers. The map also leads managers to spend more of their resource on that group of factors which have stronger impacts on planning process.

The proposed FCM enables the managers to augment their jobs by establishing and developing scenarios and evaluating the alternative paths to reach the better strategic information system plans. On the other hand, the model’s state of being dynamic enables the managers to establish and analyse specific scenarios for different categories of the plans. Due to the diversity of the categories of the plans and even the diversity of culture in different regions, different solutions to increasing the applicability of the plans are available. This map, by producing a clear picture of the affecting factors, is a good means for managers to help them identify the solutions and alternatives.

Scenarios help the users understand the process of planning and state and analyse their own ideas about the future changes. The proposed FCM can be used as a basis for establishing scenarios for the following purposes:

- evaluating the capabilities of the organisation for gaining the suitable plans
- analysing different alternatives for determining the planning factors.

7 Conclusions and future research

Handling the SISP has always been important to the managers. On the other hand, the strategic factors involving this notion are complicated and vague and cannot be easily quantified. There are lots of qualitative techniques to analyse the structured problems, but these techniques are not sufficient for analysing such problems. In order to deal with such problems, former researchers focused on SISP success, and its factors and problems, the role of top management, SISP process, IS planning methodologies and approaches, planning scope, business change, IT change, and their alignment, and various other aspects of the planning process. However, less attention is paid on contextual factors of SISP process. Thus, this research tried to fill the gap by utilising FCM for simulating the planning process.

In this paper, the usefulness of the FCM for modelling and simulating the SISP has been studied. The proposed model is applicable to establishing projects and augmenting the SISP process. Using it, various businesses and practitioners are able to effectively design and implement the process. It is noteworthy to mention that limited access to experts in the field of SISP could be considered as the main limitation of this research. For future research, it is proposed to design an expert system based on the FCM which could be adjusted to different organisational environments. It is also advisable to use other methods of determining the fuzzy weights. Finally, this paper leads to proposing a new method for determining and demonstrating the SISP process. The model considers various variables and enables the managers to study the effects of different factors on the planning process.

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